geris; scutello distincto; elytris ovatis, rufo-piceis, maculatim silaceo-squamosis, sulcato-punctatis, punctis elongatis, subremotis, interstitiis leviter carinulatis, humeris haud prominulis, apice rotundatis; corpore infra pedibusque piceis, vage squamigero-punctatis. Long. 3 lin.

Hab. South Australia.

Melanterius cinnamomeus.

M. ovalis, rufo-ferrugineus, squamosus; rostro tenui, æqualiter punctulato; antennis testaceis; prothorace subtransverso, utrinque rotundato, crebre punctulato, punctis unisquamigeris; scutello scutiformi; elytris subtrigonatis, sulcato-punctatis, interstitiis latis, subplanatis; corpore infra pedibusque disperse niveo-squamosis. Long. $2\frac{1}{3}$ lin.

Hab. Champion Bay.

These are two very distinct species, differing in sculpture and coloration from the three hitherto described.

Melanterius servulus.

M. niger, subnitidus; rostro ferrugineo, nitido; antennis rufo-testaceis; prothorace creberrime punctulato; elytris sulcatis, punctis elongatis angustis impressis, interstitiis fortiter carinatis ex fere impunctatis; corpore infra nitido, remote squamoso-punctato; pedibus ferrugineis, squamulis filiformibus argenteis adspersis. Long. $1\frac{3}{4}$ lin.

Hab. King George's Sound.

Allied to *M. porcatus*, Er., but smaller, the prothorax very closely punctured, the intervals forming a sort of reticulation, and the elytra with long narrow punctures in their grooves.

XVIII.—*On some Recent Researches in Vegetable Physiology.* By M. Marc Micheli*.

In the present state of our knowledge we can scarcely expect brilliant discoveries or works to make a great noise in the world. This may be the case in the infancy of a science; but the task which we have to fulfil is essentially different. Our predecessors have laid down the great principles; and in a general way we may say that science rests upon firm and solid bases which nothing can overturn. What remains for us is deep and minute investigation; we must not neglect any detail, however minute it may appear. It is only by following this course, which is perhaps more arid and which, from afar,

* Translated by W. S. Dallas, F.L.S., from the 'Bibliothèque Universelle, Archives des Sciences,' tome xlii. pp. 105–134, October 1871.

may appear more ungrateful, that the scientific men of the present day will succeed in perfecting the work which has been commenced, and introduce into the sketch which has been handed down to us the finish of a perfect picture.

These general reflections, which I believe to be true for all the sciences, apply particularly well to vegetable physiology.

The principal features of the life of plants are known to us; and we can nearly follow the different phases of development from the first vital movements of the germinating seed to the moment when the products of vegetation are accumulating in the fruit and thus preparing a new generation.

But if the general outlines are known, how many details are still wanting! how many phenomena which escape us, at all events in part! how many questions to be solved!

The number of those who devote themselves to this task is great; and if we wish to give a sketch of the present state of science, we are only embarrassed to choose in the midst of the materials which present themselves on all hands. All nations assist in the work, but none so much as the Germans. Since the time of De Candolle vegetable physiology has shown a tendency to naturalize itself in Germany; and although we can cite among the naturalists belonging to other nations many names which are advantageously known to us, it is nevertheless to the Germans that we must give the honour of most of the very modern discoveries, and of those which have most contributed to give the science its present form and tendencies.

Whilst the works are numerous, their very form renders them difficult to analyse; many may be said to be only accounts of extremely minute experiments which it is impossible to depict in broad lines. We must not expect to find in them striking results of a kind to open up new horizons. Some only confirm already-known facts; others introduce slight modifications of these without changing their general character.

I.

At the base of physiological researches we shall always find those which treat of the relation of the plant and of light, and particularly of the interesting and varied part played by chlorophyl in vegetable life.

Professor Sachs was the first to indicate the curious and unexpected phenomenon of a diminution in the intensity of the colour of chlorophyl under the direct influence of the sun's rays*. In other words, if a portion of the leaves is sheltered by a screen of some kind, it soon contrasts by its darker colour with the other parts, which are exposed to the sun.

* Physiologie végétale, trad. Franç. p. 16.

The cause of this phenomenon has exercised the sagacity of physiologists; and it has finally been recognized that this change of colour was only apparent, and that it resulted from certain movements performed by the granules of chlorophyl in the interior of the cell.

The first observation of this kind is due to M. Famintzin*, author of numerous investigations upon light and vegetation. He observed that in the leaves of certain mosses (*Mnium*, sp.) the granules of chlorophyl group themselves during the day in the cells along the horizontal walls or those parallel to the surface. During the night they execute a movement of retreat and place themselves along the walls perpendicular to the surface. This phenomenon is exclusively due to the influence of light; heat has nothing to do with it.

Of the different rays the most refrangible alone have the faculty of drawing the chlorophyl towards the surface. The most luminous rays produce the same effect as complete darkness.

These results being once known, the same subject was taken up and treated more profoundly by M. Borodin†. He studied a great number of plants, both cryptogamous and phanerogamous. Among the latter he especially paid attention to those whose transparent tissues rendered observation easy (*Callitriche*, *Stellaria*, *Ceratophyllum*, and *Lemna trisulca*). He recognized three different phases in the phenomenon. Like M. Famintzin, he saw the chlorophyl place itself along the horizontal walls under the influence of light, and retire in darkness: but he likewise remarked that too ardent a sun exerts the same action as darkness; under the influence of its rays the granules of chlorophyl quit the horizontal walls and move towards the perpendicular ones. This action fully suffices to explain the changes of colour indicated by M. Sachs. In fact in diffused light the chlorophyl covers the horizontal walls (or those which alone strike our eyes), and the leaf thus appears darker. In the open sun or in obscurity these same walls, being almost completely deprived of chlorophyl, of course give us the impression of a lighter tint.

With regard to the effect of the different regions of the spectrum, M. Borodin perfectly agrees with his predecessor.

Researches of the same kind have also been made by M. Prilleux‡ upon the leaves of a moss (*Funaria hygrometrica*).

* Pringsheim's Jahrb. für wiss. Botanik, Bd. v. p. 49.

† Mélanges Biologiques tirés du Bull. de l'Acad. Imp. de St. Pétersb. tome vii. (1869) p. 50; and Bot. Zeit. 1869, No. 38.

‡ Comptes Rendus, 1870, tome lxx.

His results agree in all respects with those of the two naturalists above mentioned.

Lastly, M. Roze* concludes some investigations of the same kind by saying that these movements of the granules of chlorophyl must be accompanied by a displacement of the whole protoplasmic mass. The anatomical relations of the different parts of the cell render this, so to speak, necessary and evident.

By taking up similar researches, Dr. B. Frank† has discovered an entirely new property of chlorophyl, a property the importance of which cannot be well appreciated except by his subsequent investigations. According to Dr. Frank, the granules of chlorophyl unite to all the other characteristic features of their already complicated organization a marked tendency to move in the interior of the cell to the side which is most illuminated, exactly as zoospores do when placed in a plate near a window. To ascertain this phenomenon we must of course have recourse to plants with rather large cells, such as are often presented by aquatic plants. The first observations were made on leaves of *Sagittaria sagittifolia*, a plant of which was grown near a window. The general distribution of the granules of chlorophyl during the day and night at first followed strictly the laws laid down by MM. Famintzin and Borodin; but as the unilateral illumination was prolonged the aspect of affairs changed, and the granules of chlorophyl showed a more and more marked tendency to accumulate on the most strongly illuminated side of the cell.

The same facts were reproduced in the cells of the prothallium of various ferns and in the leaves of a moss, the *Mnium rostratum*, Schwægr. The position, direction, or orientation of the cells has no influence upon the phenomenon, which is equally well manifested in all cases, in diffused light as well as in the sun's rays. With regard to the different regions of the spectrum the author was unable to make any marked distinction. In a general way, diminution of the intensity of the light renders the phenomenon less striking and sometimes irregular; it is, however, always manifested, whatever may be the colour of the luminous rays.

Dr. Frank thought he could associate this displacement of the grains of chlorophyl with peculiar protoplasmic currents. Perhaps this work will become the origin of interesting observations upon the relations of light to the intracellular currents, phenomena which are still very imperfectly known.

As we are speaking of movements, we may indicate in

* Comptes Rendus, 1870, tome lxx.
† Botanische Zeitung, 1871, No. 14.

passing the observations of M. Bert* on those of the so-called sensitive organs in coloured light. These are the only researches upon this subject with which we are at present acquainted. According to this author, plants of *Mimosa pudica* kept in the dark died at the end of twelve days, having lost all sensibility after the seventh. Other individuals of the same species were enclosed in lanterns of coloured glass, which was, as far as possible, monochromatic; and the following is a summary of the results obtained:—

In green light the plants died in sixteen days; sensibility persisted for twelve days.

In violet light the plants lived three months without any development, and then perished; sensibility persisted to the end.

In blue light the plants continued to live without development; they constantly retained a certain degree of sensibility.

Lastly, in yellow and red light the plants not only live but become slightly developed; they retain their sensibility.

If we now approach the important subject of the decomposition of carbonic acid and the assimilation in the grains of chlorophyl, we shall find that here also some advances have been made, and we shall have to refer to works of greater importance.

It is a fact that often presents itself in the history of the sciences, that the first observers, perhaps carried away by the charm of discovery and by the desire to render it as evident as possible, give a somewhat too absolute value to the results which they have obtained, and it is only at a later period and by little and little that the facts appear in a perfectly correct light. Thus it was formerly regarded as a perfectly positive law that the most luminous rays of the spectrum alone acted in the phenomenon of assimilation, a different part being assigned to the more refrangible rays. In other words, the action of light upon chlorophyl seemed to be directly opposite to its influence upon chloride of silver. Repeated and more profound researches have already greatly modified this notion. We shall now endeavour to give an exact idea of the state of the question by rapidly going through the various works which have come to our knowledge. We shall simply follow the chronological order, leaving entirely on one side the questions of priority which, as a matter of course, have sprung up.

The first in point of date is M. Gregor Krauss†, one of the most accurate of observers, and author of several important treatises. He resumed the investigations of M. Famintzin

* Comptes Rendus, 1870, tome lxx.

† Pringsheim's Jahrb. vii. p. 511.

upon the production of starch in coloured light, and expresses himself in opposition to the assertion of that author, that no trace of starch is produced under the influence of the blue rays.

M. Krauss has followed the experimental methods indicated by M. Sachs, in seeking the smallest traces of starch in the tissues, and employed, as a coloured medium, the large double bells also invented by that eminent observer. The interval between the two bells is filled with a solution of bichromate of potash for the least refrangible part of the spectrum, and with a solution of ammoniacal oxide of copper for the more refrangible rays.

Different aquatic and terrestrial plants vegetated successively in these apparatus (*Spirogyra*, *Funaria hygrometrica*, *Elodea canadensis*, *Lepidium*, &c.). The result was constantly the same; in the three bells employed (with white, yellow, and blue light) starch was formed. The only difference between them was one of proportion and promptitude. Thus in white light and in the sun the first traces of starch were visible in five minutes; in blue light, only an insolation of several hours was capable of producing an appreciable effect.

The temperature also exerted a certain influence, but only in the proportion in which it acts upon vegetation in general. When the heat is greater, vegetation is more active, and it is therefore very natural that a greater quantity of starch should be produced. But this effect is not due to a direct intervention of the caloric element in the phenomenon; for the production of starch, although very slight, is still appreciable at a temperature at which most of the other functions are suspended.

A check experiment, made, by means of the balance, upon cotyledons of *Lepidium* and *Linum*, showed, by a notable augmentation of weight, that the starch was formed in them from the elements, and that it was not a product of transformation.

M. Prilleux* has taken up the idea that the effect attributed by his predecessors to the refrangible rays themselves was rather due to the diminution of the luminous intensity. In the experiments of M. Famintzin upon *Spirogyra*, he says, the light which traverses the solution is so feeble that it is incapable, by itself, of producing a marked effect. According to this author, the assimilant faculty of the leaf is proportional to the illuminating-power of the rays which it receives.

* Comptes Rendus, 1870, tome lxx. p. 521; Ann. des Sci. Nat. 5e sér. tome x.

He operated with a solution of ammoniacal sulphate of copper, not too much concentrated, and exposed his apparatus to the full light of the sun or to the focus of a powerful lens illuminated by a strong petroleum lamp.

M. Baranetzky* has resumed this subject, finding that M. Prilleux had operated upon very thin layers of liquid, which allowed too many rays to pass, this naturally invalidating his results. He employed ammoniacal oxide of copper and protochloride of iron, which, in layers of 25 millims. thickness, divided the spectrum pretty accurately into two more and less refrangible halves, but each endowed with nearly the same illuminating-power. The results were exactly the same; with an equality of luminous intensity, the number of bubbles of oxygen evolved during the act of assimilation was the same. This applies also to the greening of etiolated chlorophyl, and to the destruction of the colouring principle in an alcoholic solution of chlorophyl under the influence of the luminous rays. Heliotropic curvatures alone evade this law, and are manifested only under the influence of the blue or neighbouring rays.

The following is the mode in which, in the present state of our knowledge, M. Baranetzky proposes to describe the action of light:—

a. The decomposition of carbonic acid or assimilation, the formation of chlorophyl, and the destruction of the colouring principle are phenomena solely dependent on the degree of luminous intensity.

b. Heliotropic curvatures, the periodical movements of organs, the currents of protoplasm, and the changes of place of the grains of chlorophyl are executed only under the influence of the most refrangible rays.

On the decomposition of carbonic acid in the leaves, Dr. Pfeffer has published a work† which is perhaps the most complete that we possess on this subject. From the perfection of the methods employed, and the care with which the experiments were conducted, this work will always continue to be of very great value. The conclusions, although not so clear and precise as those of MM. Prilleux and Baranetzky, are nevertheless in the same direction, and tend to give the preponderance to the illuminating-power in the direct action of the luminous rays. He expresses them in the following terms:—

"The rays of the spectrum perceptible to our eyes are the

* Botan. Zeitung, 1871, No. 13.

† Arbeiten des Botanischen Instituts in Würzburg, Cahier i., 1871.

only ones which can become the cause of the decomposition of carbonic acid. The rays endowed with the most considerable illuminating-power (the yellow rays) exert of themselves an influence equal to that of all the others taken together. The most refrangible rays possess only a much less marked action. To each spectral colour there belongs a certain degree of activity in the phenomenon of assimilation, a degree which remains the same whether the rays act isolatedly upon plants, or whether their action is combined."

To arrive at the greatest possible exactitude, M. Pfeffer passed over the different methods which consist either in counting the bubbles of gas or in measuring the quantities of gas which have escaped from a plant vegetating under water. He adopted the method of M. Boussingault, who made his plants vegetate in a closed vessel, the atmosphere of which contained known quantities of carbonic acid. As coloured liquids he employed chromate of potash, ammoniacal oxide of copper, aniline red, orselline, aniline violet, and chlorophyl, and also, in order to observe the effect of the obscure heat-rays, a very concentrated solution of iodine in sulphide of carbon. We cannot, however, describe the apparatus and experiments; for these details we must refer the reader to the memoir itself.

We may say, only, that from the commencement of his investigation M. Pfeffer foresaw that the effects of the two halves of the spectrum separated by the chromate of potash and the ammoniacal oxide of copper represented, when taken together, a total nearly equal to the action of white light. This was already a great step made towards the idea of the predominant action of the luminous intensity. It is in consequence of this observation that M. Pfeffer, by employing sometimes monochromatic liquids, sometimes liquids which only excluded one or two spectral colours, has succeeded in nearly determining the assimilant power of each ray. If in white light chlorophyl decomposes 100 parts of carbonic acid, the isolated rays give the following numbers:—

Red and orange	32·1
Yellow	46·1
Green	15·0
Blue, indigo, violet	7·6
Total	100·8

We may therefore truly say that the action of the combined light represents the sum of the partial actions which the isolated rays would exert. The knowledge of these numbers enables the author to construct the curve of assimilation. This curve, which is nearly parallel to the curve of luminous intensity, attains its culminating point between the Fraunhofer lines D and E. On the other hand it has nothing to do with the curve of calorific intensity, which follows a totally different course.

Finally the author was led to confirm his results by data as to the augmentation of weight acquired by plants under the influence of the different regions of the spectrum. These data are derived from unpublished experiments by Prof. Sachs; their author has ascertained that even in blue light there is an increase of weight, which is certainly very slight, but greater than it appears at the first glance, since we must take into account the loss of solid material due to respiration. In yellow light the increase of weight represented 35 per cent. of what it would have been in white light.

The study of the diffusion of gases in the interior of the plant seems to be naturally connected with that of the conditions under which assimilation is performed; but although the results of such researches belong to pure physiology, the course by which we arrive at them, and the experiments and apparatus employed, all belong rather to the domain of physics. The most difficult problems of molecular physics are implicated in the questions which have to be solved. Therefore we shall confine ourselves to indicating, *en passant*, a very important and complete work upon this subject from the pen of M. N. J. C. Müller*, still in course of publication in Pringsheim's 'Jahrbücher für wissenschaftliche Botanik.' We shall only say that the author adopts the idea that, in the normal state of a membrane, the solid nuclei (formed of cellulose substance and mineral incrustations) and the liquid layers which surround them (molecular theory of Nægeli) always leave between them free spaces, actual pores.

Before quitting the subject of the exchanges of gas between plants and the circumambient atmosphere, we may mention two other observations, due to French naturalists.

M. van Tieghem † has observed the well-known phenomenon of aquatic plants which, although incapable of producing any current of bubbles of gas under the influence of diffused light, set them free in abundance as soon as they are struck by the rays of the sun; but what he has remarked that is new, is that this effect does not cease immediately with the insolation. A

* "Untersuchungen über die Diffusion atmosphärischer Gase in der Pflanze," Pringsheim's Jahrb. vols. vi. & vii.

† Ann. des Sci. Nat. 5e sér. tome ix. p. 269.

plant of *Elodea canadensis* which had received the rays of the sun for three hours, continued to produce currents of gaseous bubbles in diffused light, and did not stop until nine hours afterwards, when the night had already long come on. In another experiment, an insolation of one hour produced gaseous currents which were continued for three entire hours in complete darkness. According to these observations, therefore, the vegetable tissues are in a manner endowed with the property of storing up the solar light. Such a phenomenon as this may enter into the group of those which are designated under the name of phosphorescence.

M. Barthélemy* has investigated the function of the cuticle (that uniform layer which in general clothes the epidermis of plants) in accordance with the principles of Graham with regard to colloids. He has arrived at the conclusion that, in the exchanges of gaseous molecules between the plant and the atmosphere, the oxygen and carbonic acid pass especially through the cuticle (upper surface of the leaves), whilst the nitrogen makes a way for itself through the stomata (lower surface).

To the phenomena which the action of the luminous rays give rise to in the plant, those which originate in the absence of these same rays are most naturally related. It is by this title that a curious work by M. Krauss† on the causes of the deformation of etiolated plants figures here. These changes are well known, and present themselves under two apparently very different forms; certain organs, and especially the limbs of the leaves, when in the dark, undergo a complete arrest of development, and are far from acquiring their normal dimensions; others (for example, the internodes of the stems) become, on the contrary, much more elongated than usual, and attain dimensions several times exceeding their normal size.

These apparently irreconcilable anomalies depend upon entirely different properties of the tissues.

The etiolated leaves are arrested at the point at which, under normal conditions, they would have begun to receive the luminous rays—that is to say, at their issue from the scales of the bud. From this moment a normal leaf is called upon to suffice for itself; starch soon makes its appearance in the cells whose position brings them first into relation with the luminous rays—that is to say, in those of the teeth, nervures, &c. It is upon this starch that all the subsequent growth of the leaf depends; that which is enclosed in the interior of the

* Ann. des Sci. Nat. 5e sér. tome ix. p. 287.
† Pringsheim's Jahrb. vii. p. 209.

older tissues is of no use to it. In darkness no starch is prodnced; aud it is therefore not surprising that development is arrested. This view is so accurate that certain cotyledons destined to display a foliaceous structure stop growing in darkness at the moment when they ought to issue from the ground, although their cells are still full of the sugar or oil which was accumulated in the seed.

The exaggerated length of the internodes is due to very different causes, and is related to the phenomena of tension which always intervene in stems between the medulla, or active part, on the one hand, and the ligneous and cortical cells, or passive parts, on the other.

From an anatomical point of view the etiolated internodes are distinguished by presenting all the characters of very young internodes just issuing from the bud; the thickening of the walls of the ligneous and cortical cells which characterizes adult stems is here completely absent. This thickening, indeed, is related, by bonds which are not yet very exactly understood, to the presence of leaves on the internode. In darkness, the leaves not being developed, the cells retain the primitive thinness of their membranes.

This being understood, the elongation of the etiolated stems is easily explained, thanks to the intervention of two factors. In normal stems the medulla has always a tendency to elongate; it is the peripheral layers that arrest it; in young stems these are subjected to a tension strong enough to cause them to shorten considerably when they are isolated. But in proportion as their walls become thickened the resistance becomes more effective, and we see this in the fact that their contraction when they are separated from the rest becomes less and less. In darkness their walls do not thicken, and nothing is opposed to the elongation of the medullary cells. This is the first factor.

With regard to the pith itself, M. Krauss has already shown, in a former work*, that it has the property of elongation solely by the interposition of aqueous molecules between the cellulose molecules. This interposition may take place in the etiolated as in the normal plant; the pith is therefore the only part of the plant which continues to *grow actively* in the dark. This growth is precisely the second factor of the elongation of the internodes; and by combining it with the absence of resistance in the peripheral layers, we can understand that considerable results may be produced.

By the side of the effects of light, the investigation of those of temperature quite naturally finds its place.

* Botan. Zeit. 1867, Nos. 17, 18.

With regard to the degree of cold which living plants are able to support, M. Goeppert of Breslau* calls attention to the fact that the lowest temperatures ascertained in the polar regions ($-40°$ to $-52°·6$ F.) only relate to a very restricted number of plants. Those whose stem is not sufficiently high to pass the layer of snow are under very different conditions. Sheltered under a screen which is a bad conductor of heat, these plants are subjected to a temperature which hardly falls below 28°·4 F. But if the snow protects them from too sharp a cold, and becomes the indispensable preserver of plants in high latitudes and on the mountains, their development is none the less arrested. The plants best known as flowering in winter, *Helleborus fœtidus* and *niger* and *Bellis perennis*, cease growing as soon as the temperature is low; they merely do not suffer from frost: a half-opened flower may be completely stiffened by the cold for several days; but as soon as the thaw comes, it resumes its development.

In our latitudes, the heat of summer, by heating the soil, may exert a certain influence upon winter vegetation. In the arctic regions this is not the case: the soil, always frozen, does not retain any heat; all must come from the sun; and it is thus that we sometimes see plants (willows, rhododendrons) frozen in their lower parts, and bearing at the extremities of their branches leaves and expanded flowers.

It must not be supposed that a plant because it is frozen is for this reason protected from the deleterious influence of a sharper cold. Each species can bear a certain diminution of temperature: some may, without injury, be completely frozen and afterwards thawed; but for each there exists a certain minimum which cannot be passed without producing fatal consequences. However, M. Goeppert, who has devoted himself for many years to the study of the relations of temperature and vegetation, gives us hopes of more ample details upon this curious subject.

It has often been asked, at what moment do frozen cells perish? at their freezing or their thawing? It is difficult to give an answer to this; and direct experiments are almost impossible. It is evident that all the cells which may freeze or thaw several times without injury only perish when the thawing takes place under unfavourable circumstances; it is a well-known matter of experience that if, after a cold night, the temperature rises gradually and the sky remains cloudy, many plants, even young delicate shoots, recover perfectly. If, on the contrary, the sun causes too rapid a thaw, the evil acquires

* Botan. Zeit. 1871, Nos. 4 & 5.

very different proportions. But a multitude of plants occur under very different conditions, and perish as soon as their cells have felt the attacks of frost. At what precise moment do they die? M. Goeppert * cites in connexion with this an observation (an isolated one, it is true, but still curious) which seems to prove that it is the direct action of cold, the frost itself, that kills delicate plants. Two tropical Orchideæ, *Phajus grandifolius* and *Calanthe veratrifolia*, contain considerable quantities of indigo in their flowers. This substance, as every one knows, is colourless in living plants, and only becomes blue after their death, by a phenomenon of oxidation. The flowers of these two plants are of a fine white colour; but it is only necessary to rub them a little hard with the hand to bring out in them the natural tint of indigo. Cold produces exactly the same effect: as soon as the flowers are frozen, no matter to what extent, their corollas immediately become deep blue; and this colour persists after thawing. In this case, at least, the cells have been killed by the direct action of cold.

One of the most characteristic features of the cells which have suffered from frost is the modification of their endosmotic properties: they lose their turgescence, and the liquid which they contain escapes through their walls without the least effort. M. Sachs has sought the explanation of these facts in the modifications which the molecular structure of the membrane suffers under the influence of thaw. If this comes on suddenly, the shock destroys the existing molecular equilibrium. This would be an effect similar to that which we observe under analogous circumstances in white of egg or starch-paste. After thawing, these two substances no longer present any thing but a spongy mass without consistency, allowing the liquid which they contained to escape under the smallest pressure.

M. Prilleux † has opposed this opinion, which presupposes, according to him, the formation, in the invisible pores of the membrane, of icicles, which, by their fusion, would overthrow the molecular equilibrium. Now the properties of capillary spaces, and the difficulty of causing water to freeze in them, are by no means favourable to this theory. The properties of the frozen cells being exactly the same as those of cells which have passed through boiling water, M. Prilleux proposes to seek the explanation of the phenomenon in the alteration of the protoplasm, and not of the membrane. It is, in fact, upon the diosmotic properties of the primordial utricle that the separation of the different liquids enclosed in the different cells

* Botan. Zeit. 1870, No. 24.

† Bull. Soc. Botan. de France, 1869, xvi. p. 91.

depends. When life no longer exists, then the acids mix with the bases, and the coloured substances spread through the tissues. The simple fact of the death of the protoplasm would therefore suffice, according to M. Prilleux, to explain all the properties of the frozen cells.

As to the sheets of ice which are often seen during the winter at the surface of stems or beneath the epidermis, these originate, according to the same author *, from the water of constitution of the membranes. Each molecule retains around it, by the forces of attraction with which it is endowed, a liquid layer of a certain thickness; under the influence of cold, the force of attraction diminishes, and a part of the liquid flows away and becomes frozen at the surface.

[To be continued.]

XIX.—*Observations on the Systematic Relations of the Fishes.* (Abstract). By Prof. Edward D. Cope †.

I. Preliminary.

The system of fishes, as at present adopted in America, is the result of the labours of many naturalists, but chiefly of Cuvier, Agassiz, Müller, and Gill. Without going into the history of the subject at present, it will be proper to point out the principal modifications of Cuvier's system introduced by his three successors. The orders of Cuvier were:—the Chondropterygii, Malacopterygii, Acanthopterygii, Plectognathi, and Lophobranchii.

Professor Agassiz, under the name of Placoids, adopted the first division; the second he called the Cycloids, the third Ctenoids, and then created a fourth order under the name of Ganoids, which should embrace a portion of Cuvier's Chondropterygii (the Sturgeons), a portion of the Malacopterygii Abdominales (the Bony Gars &c.) and the two last orders of Cuvier. Professor Müller, following with a still more complete anatomical investigation, especially into the soft parts, discerned three subclasses in Cuvier's Chondrostomi, which he named the Leptocardii (Lancelet), Dermopteri (Lamprey &c.), and the Selachii (Sharks &c.). In the then recently discovered *Lepidosiren* he saw a fourth subclass, Dipnoi.

Having instituted an investigation of Agassiz's Ganoid order, in an able memoir he purged it of the Plectognath and

* Bull. Soc. Botan. de France, 1869, xvi. p. 140.

† From the Association Number of the 'American Naturalist.' Communicated by the Author.